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The Reproductive Biology of Two Common Surfzone Associated Sciaenids, Yellowfin Croaker (*Umbrina roncador*) and Spotfin Croaker (*Roncador stearnsii*), from Southern California

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Abstract.—Yellowfin croaker (*Umbrina roncador*) and spotfin croaker (*Roncador stearnsii*) were collected from San Clemente, California from May through September 2006. Both species were analyzed to determine batch fecundity. Yellowfin croaker ovaries were also histologically examined to describe their summer spawning activity. Batch fecundity in spotfin croaker (n = 13) females ranged from 35,169 to 640,703 described by the equations $BF = 1.59E\text{-}07SL^{5.01}$ for length and $BF = 13.51W^{1.60}$ for total body weight. Yellowfin croaker (n = 16) females batch fecundity ranged from 99,259 to 405,967 and was described by the equations $BF = 2.4E\text{-}04SL^{2.02}$ for length or $BF = 0.33W^{0.68}$ for total body weight. Yellowfin croaker spawning was determined to begin by June and end by September.

Introduction

Croakers (Family Sciaenidae) comprise a significant portion of the nearshore ichthyofauna of southern California. Nearshore gill net surveys by Pondella and Allen (2000) reported yellowfin croaker (*Umbrina roncador*) as the most abundant species along the mainland and third most abundant at Santa Catalina Island whereas spotfin croaker (*Roncador stearnsii*) was not among the 25 most abundant species in either area. Generally, the greatest localized concentrations of both species occur in less than eight meters of water, typically just outside the surf zone along southern California beaches south of the Los Angeles/Long Beach Harbor complex (O'Brien and Oliphant 2001; Valle and Oliphant 2001). Yellowfin croaker nearshore abundances are strongly correlated with sea surface temperature, both inter- and intra-annually, with abundance typically peaking during the summer months (Pondella et al. 2008). These authors suggested that these peak summer abundances may be related to reproductive activities as gonosomatic indices (GSI) for yellowfin croaker peaked from June through August. Similar analyses of spotfin croaker have not been published. Despite their prevalence in southern California little information exists on the reproductive biology of either species. Such knowledge is needed for the successful management of the recreational fishery.

Fecundity, batch or total, is undocumented for most southern California sciaenids with the exception of white croaker and queenfish (Love et al. 1984; DeMartini and Fountain 1981), but is available for some of the more valuable commercial fisheries in California, such as northern anchovy (*Engraulis mordax*) and Pacific sardine (*Sardinops sagax*) (Hunter and Goldberg 1980; Hill and Crone 2005; Lo et al. 2005; Hill et al. 2006). Availability of reproductive dynamics (fecundity, spawning seasonality, etc.) for northern

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anchovy and Pacific sardine has substantially increased the tools available to fishery managers, namely their use in the development of stock assessments (Hill and Crone 2005; Lo et al. 2005; Hill et al. 2006). The general lack of such basal information further restricts such assessments of yellowfin and spotfin croaker population dynamics. While knowledge of the reproductive parameters are only a portion of the necessary life history metrics needed for stock assessments, the present study was designed to help fill some of these data gaps. The batch fecundity was calculated for each species while the summer spawning cycle was histologically identified for yellowfin croaker. Funding was not available to conduct histological analysis of spotfin croaker.

Materials and Methods

Sample collection.—Both species were collected during monthly impingement surveys at San Onofre Nuclear Generating Station (SONGS) in northern San Diego County, California, following the techniques described in Miller (2007). Individuals were sexed by visual examination of intact gonads, measured to the nearest millimeter (mm) standard length (SL), and weighed to the nearest gram (g). All samples for both species were collected between 10 June to 15 September 2006. A total of 86 yellowfin croaker were collected, 51 female and 35 male, with male lengths ranging from 163–309 mm SL and females 172–340 mm SL. Twenty-six female spotfin croaker were collected with individuals ranging from 202 to 306 mm SL.

Histological analysis of gonadal state.—Gonads were removed from each fish, weighed to the nearest 0.5 g, and preserved in 10% buffered formalin. All fish were larger than 150 mm SL or the size at 50% maturity (Pondella et al. 2008). Yellowfin croaker gonads were dehydrated in an ascending series of ethanol and cleared in toluene. After dehydration, samples were embedded in paraffin and histological sections were cut at 5 μm using a rotary microtome. Sections were mounted on glass slides and stained with Harris hematoxylin followed by eosin counterstain. Slides were evaluated to determine the stage of the spermatogenic cycle in males and the ovarian cycle in females. Female stages were in accordance with Goldberg (1981). Stage 1 (regressed or regressing) was the nonspawning condition consisting mainly of primary oocytes. Stage 2 (previtellogenic) consisted of slightly enlarged vacuolated oocytes. Stage 3 (vitellogenic) was characterized by yolk deposition in progress. Stage 4 (spawning) mature (ripe) oocytes predominate and some postovulatory follicles may be present. Males were characterized as spawning or regressing/inactive.

Gonosomatic index and batch fecundity.—A gonosomatic index (GSI) was derived for each individual of both species by the equation: GSI = (gonad weight × gonad free body weight^{-1}) × 100 (Barbieri et al. 1994). Only female yellowfin croaker with a GSI greater than 3.5% were included in the fecundity analysis based on Pondella et al. (2008). Preliminary data on spotfin croaker GSI indicated that peak spawning occurs from June through August, with GSI values greater than 3.5% (VRG unpub. data[2]). Therefore, spotfin croaker females with a GSI greater than 3.0% were included in the study to ensure complete coverage of spawning females in all size classes available. Ovary analysis was similar to that described by Hunter and Macewicz (1980). For both species, two subsamples of approximately 0.5 g of ovarian tissue per ovary were taken from each fish. Subsamples were taken from the posterior and medial areas of each lobe. A minimum of two independent counts of ripe oocytes (hydrated eggs) from each subsample were made under stereomicroscopy. In instances of high variation, subsamples were recounted. The

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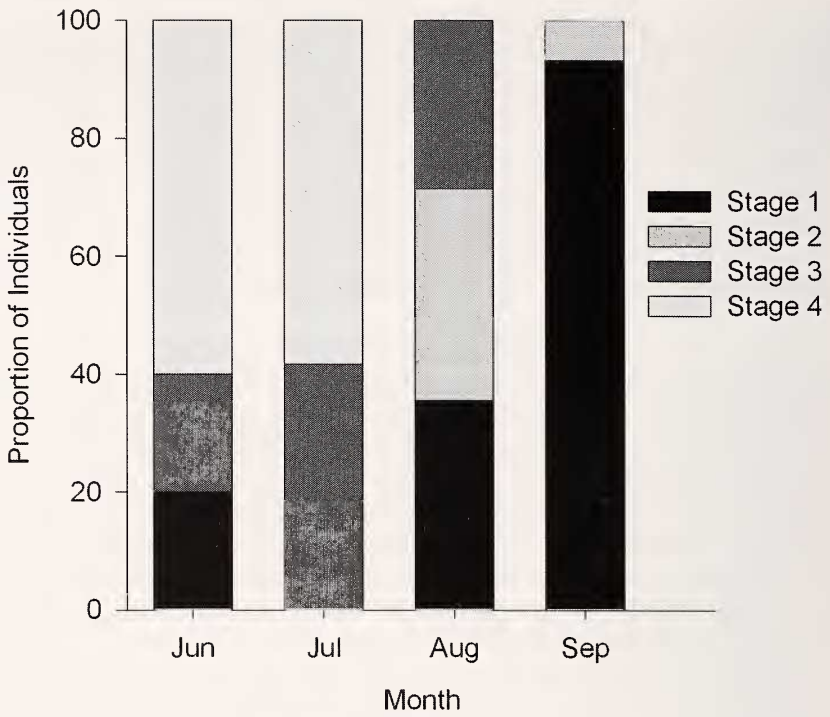

Fig. 1. Distribution of ovarian stage by month for 51 female yellowfin croaker collected during impingement sampling at San Onofre Nuclear Generating Station from June through September 2006.

mean egg count and standard error for each individual fish was calculated and later multiplied by the total gonad weight to estimate the individual batch fecundity. Batch fecundity (BF) was regressed against both standard length and total body weight to determine the relationship between both parameters.

Results

Histological analysis of gonadal state.—Histological analysis recorded peak spawning condition in July as indicated by high frequency of ripe (Stage 4) and near ripe (Stage 3) oocytes (Figure 1). Individuals collected in June also showed a substantial proportion (60%) of actively spawning individuals. No actively spawning females were collected in August, but 28% of the ovaries examined were comprised predominantly by Stage 3 oocytes. Spawning was completed by September with greater than 90% of all individuals in Stage 1 development with primary oocytes. One male with regressing testes was identified from September collections. Bimodal ovaries (spawning and vacuolated modes) were observed in five individuals collected on 24 June.

Batch fecundity analysis.—In yellowfin croaker, batch fecundity ranged from 99,259 to 405,967 ripe oocytes per female. batch fecundity increased with length ($R^2 = 0.45$, $p = 0.005$) as described by the equation $BF = 2.4E\text{-}04SL^{2.0L}$ (Figure 2a). The relationship between total body weight and batch fecundity was similar ($R^2 = 0.49$, $p = .003$) as described by the equation $BF = 0.33W^{0.68}$ (Figure 2b). Batch fecundity in spotfin croaker ranged from 35,169 to 640,703 ripe oocytes per female. Spotfin croaker batch fecundity increased exponentially with body size (SL) following the equation $BF = 2E\text{-}07SL^{5.0109}$ ($R^2 = 0.79$, $p = 0.002$; Figure 3a). Total body weight better predicted batch fecundity in

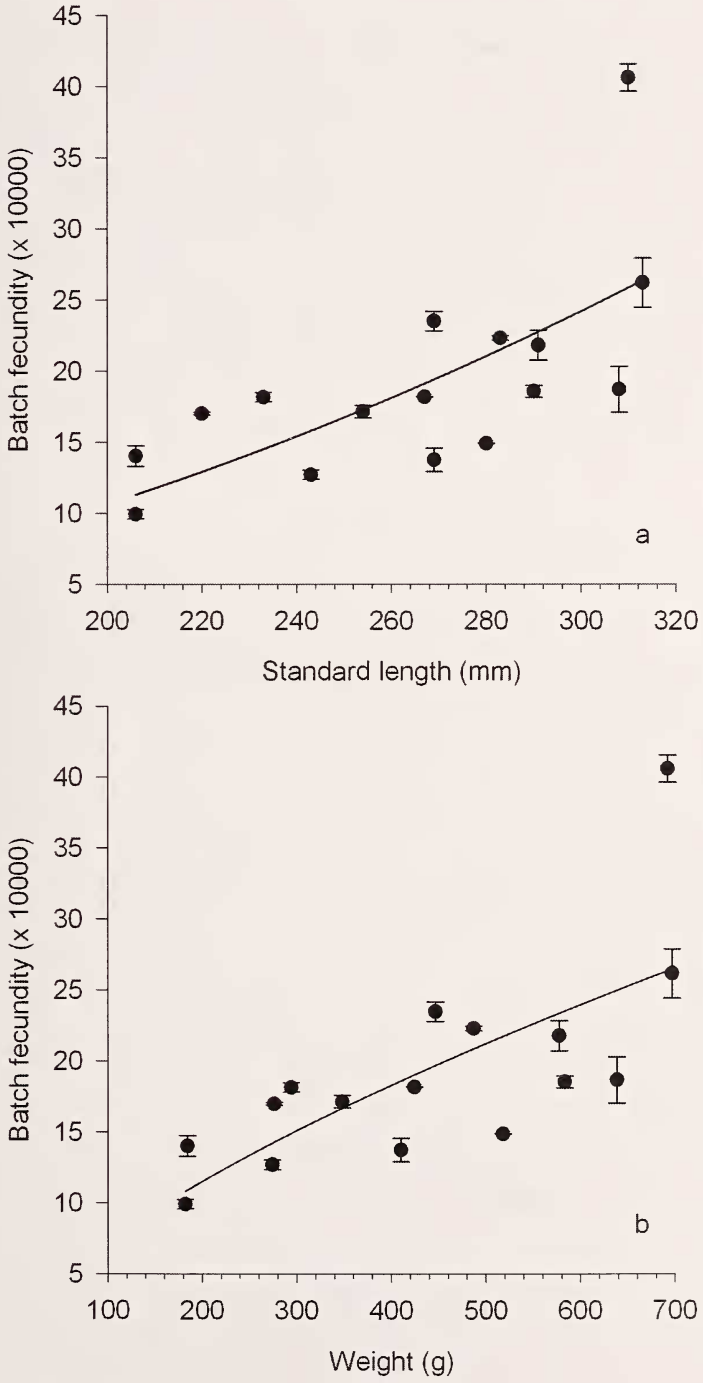

Fig. 2. Mean individual batch fecundity, ±1 standard error, by a)standard length (mm) and b) weight (g) for 16 female yellowfin croaker collected during impingement sampling at San Onofre Nuclear Generating Station from June through August 2006.

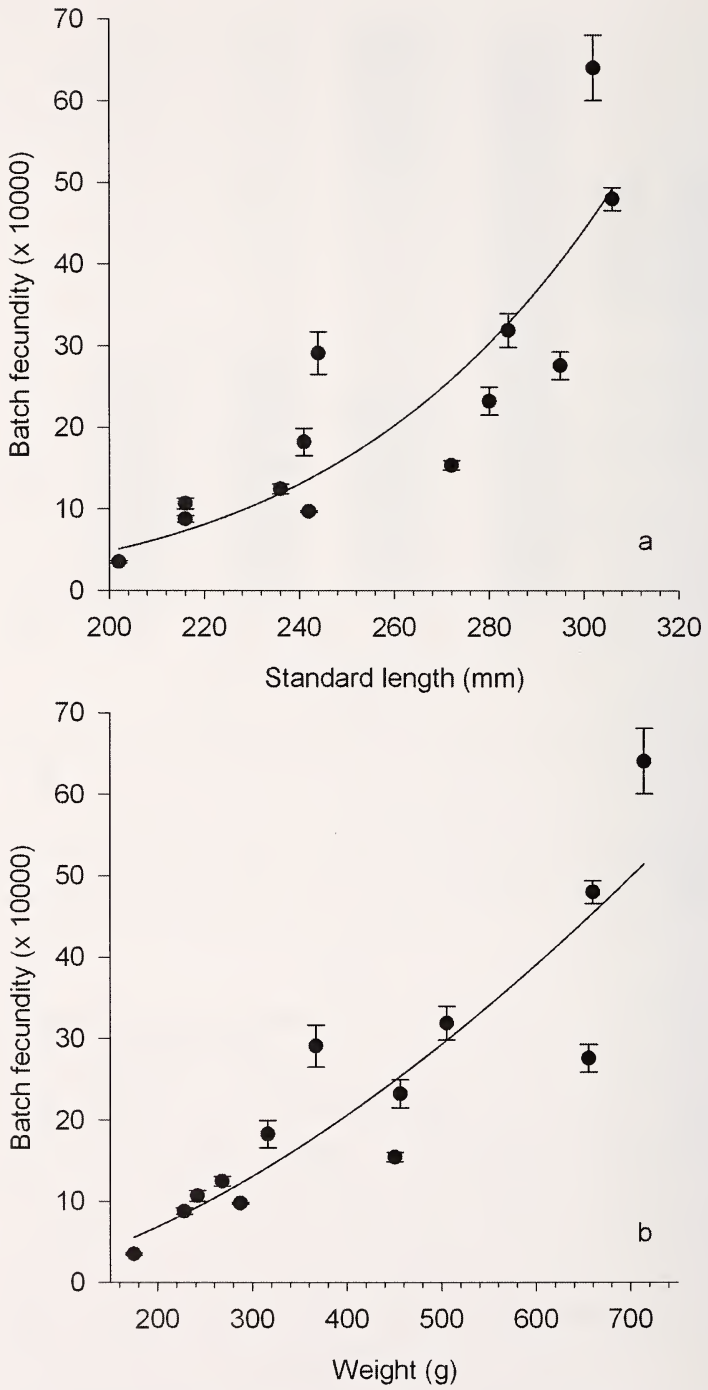

Fig. 3. Mean individual batch fecundity, ±1 standard error, by a) standard length (mm) and b) weight (g) for 13 female spotfin croaker collected during impingement sampling at San Onofre Nuclear Generating Station from June through August 2006.

Table 1. Reported batch fecundity ranges for several sciaenid species and their maximum size as reported on www.fishbase.org. Bold type indicates southern California species.

Species	Fecundity Range	Reference	Max. Size
***Seriphus politus* (Ayers)**	5,000–90,000	DeMartini and Fountain 1981	305 mm TL
***Genyonemus lineatus* (Ayers)**	800–37,200	Love et al. 1984	410 mm TL
Umbrina roncador	99,259–405,967	Current Study	560 mm TL
Roncador stearnsii	35,169–640,703	Current Study	686 mm TL
Cynoscion regalis (Bloch and Schneider)	75,289–517,845	Lowerre-Barbieri et al. 1996	980 mm TL
Cynoscion nebulosus (Cuvier)	102,369–511,859	Nieland et al. 2002	1000 mm TL
Sciaenops ocellatus	160,000–3,270,000	Wilson and Nieland 1994	1550 mm TL
Pogonias cromis	510,000–2,420,000	Nieland and Wilson 1993	1700 mm TL

spotfin croaker ($R^2 = 0.85$, $p < 0.001$) through the equation $BF = 13.511Wt^{1.6032}$ (Figure 3b).

Discussion

Yellowfin croaker and spotfin croaker reproductive patterns were consistent with previous studies of southern California sciaenids (Goldberg 1976; DeMartini and Fountain 1981; Goldberg 1981; Love et al. 1984; Miller et al. 2008; Pondella et al. 2008). With the exception of white croaker, published accounts of the reproductive life history of California sciaenids typically indicate peak spawning activity in summer concurrent with increases in water temperature in the Southern California Bight (Miller et al. 2008; Pondella et al. 2008). Pondella et al. (2008) reported yellowfin croaker abundance at SONGS increased from June to a peak in August, generally corresponding with the spawning period documented by the current study. We cannot, however, rule out the possibility of a more protracted spawning season in yellowfin croaker, as no individuals were collected prior to May in 2006, despite ongoing impingement sampling. Although recorded in all months, spotfin croaker abundance similarly peaks during the summer months (E.F. Miller unpublished data).

Fecundity estimates (batch or total) have only been published for two southern California sciaenids, queenfish (*Seriphus politus*) and white croaker (*Genyonemus lineatus*;DeMartini and Fountain 1981; Love et al. 1984). Estimates are available, however, for several Atlantic and Gulf Coast species (Table 1). As expected, batch fecundities for the southern California species generally reflect a proportional ratio between the maximum size and the maximum batch fecundity. Red drum (*Sciaenops ocellatus*) and black drum (*Pogonias cromis*) collected from the Gulf of Mexico grow to substantially larger sizes than the southern California representatives and exhibit up to an eight-fold higher maximum reported batch fecundities (Nieland and Wilson 1993; Wilson and Nieland 1994).

Unfortunately, little to no information on larval yellowfin croaker and spotfin croaker abundances were available in the primary literature to further illuminate spawning seasonality for either species (Barnett et al. 1984; Walker et al. 1987; McGowen 1993; Moser and Smith 1993). This research was able to describe some of the basal reproductive parameters for two common surf zone associated species, yellowfin croaker and spotfin croaker. Although the sample sizes were small, they were within the range of previous studies (Hunter and Macewicz 1980; DeMartini 1987) and provide a more clear insight into the life history of each species. While reserved for the recreational fishing

community, their populations still face fishery management concerns, especially in a relatively understudied area such as the southern California sandy beach surf zone. Further information on their life history parameters is needed to adequately manage these species. Specifically, the void of information on larval densities and spatial distributions should be addressed.

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